PCT/GB 9 9 / 0 1 6 2 2
09 / 7 1 9 4 1 6

GB 99/01622

The Patent Office

5

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

REC'D 13 JUL 1999
WIPO PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Signed

Dated 25 June 1999

Patents Form 1/77

Pa[redacted] 1977
(R[redacted])

THE PATENT OFFICE
12 JUN 1998
RECEIVED IN SWALE

The Patent Office

12JUN98 E367355-1 000623
P01/7700 25.00 - 9812560.2

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office
Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

P.1102

2. Patent application number
(The Patent Office will fill in this part)

12 JUN 1998 **9812560.2**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

CHART MARSTON LIMITED,
110 WHITCHURCH ROAD, AL 7/1/98
CARDIFF,
CF4 3LY,
U. K.

Patents ADP number *(if you know it)* 7444789003

If the applicant is a corporate body, give the country/state of its incorporation

U. K.

4. Title of the invention

HEAT EXCHANGER

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

J. H. MOORE & CO.,
8 GAIAFIELDS ROAD,
LICHFIELD,
STAFFS.,
WS13 7LT,
U. K.

Patents ADP number *(if you know it)* 6234520001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	9
Claim(s)	3
Abstract	-
Drawing(s)	5

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature J. H. MOORE Date 11-06-98

12. Name and daytime telephone number of person to contact in the United Kingdom J. H. MOORE - 01543 252695

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

12. A heat exchanger according to any preceding claim, in which the plates of the stack are provided at their edges with extensions to assist location of the plates in the stack.

13. A heat exchanger according to any preceding claim, in which the plates are provided with extensions in the form of loops which stack together to provide one or more tanks at the sides of the stack.

14. A perforated plate, the plate having an array of spaced column precursors, the column precursors being of thickness equal to the plate thickness and being joined together by ligaments extending between adjacent pairs of column precursors, the ligaments having a thickness less than the plate thickness.

15. A perforated plate according to Claim 14, substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

5. A heat exchanger according to any preceding claim, in which the perforations in the plates and the reduced thickness of the ligaments are produced by photochemical etching or spark erosion.

6. A heat exchanger according to any preceding claim, in which at least two differently perforated plates are used, the two plates having different ligament patterns.

7. A heat exchanger according to any preceding claim, in which the column precursors are of circular cross section.

8. A heat exchanger according to any preceding claim, which comprises a plurality of joined together stacks of the parallel perforated plates, each stack being separated from an adjacent stack by a solid unperforated plate whereby two or more separate fluid stream passageways are provided.

9. A heat exchanger according to any preceding claim, in which the perforated plates are of metal of thickness 0.5mm or less.

10. A heat exchanger according to any preceding claim, in which the components of the stack are diffusion bonded together.

11. A heat exchanger according to any preceding claim, in which the components of the stack are brazed together.

P.1102 GB

CLAIMS

1. A heat exchanger comprising a stack of parallel perforated plates, each plate of the stack having perforations defining an array of spaced column precursors, of thickness equal to the plate thickness, the column precursors being joined together by ligaments extending between adjacent pairs of column precursors, the ligaments having a thickness less than the plate thickness, the column precursors of any one plate being coincident in the stack with the column precursors of any adjacent plate whereby the stack is provided with columns extending perpendicularly to the plane of the plates.

2. A heat exchanger according to Claim 1, in which the ligaments of each plate of each pair of adjacent plates are displaced relative to those of the other plate of the pair.

3. A heat exchanger according to Claim 1 or 2, in which the top and bottom of the stack are closed by sealed plates.

4. A heat exchanger according to Claim 1, 2 or 3, in which the stack has side plates which are formed by the stacking of unperforated border regions around the edges of individual plates of the stack, the unperforated border regions being integrally formed as part of the plate.

When plates 20 and 30 are stacked together with their column precursors aligned, the effect is shown in Figure 6, where plate 20 is shown above plate 30. Hence only column precursors 21 are visible.

The double headed arrow indicates possible flow directions when the plates are stacked to form a heat exchanger.

As can be appreciated when a plurality of pairs of plates 20 and 30 are stacked together, the ligaments 22A, 22B, 32 and 33 provide a tortuous path in addition to the need for the fluid to pass around the columns that are formed from the stacked column precursors. Thus excellent heat transfer properties can be achieved.

The invention is not limited to the embodiments shown. For example, it is possible to form the plates with the ligaments of thickness equal to the plate thickness and the column precursors of thickness less than the plate thickness. In these circumstances, of course, the ligaments effectively become the column precursors and the column precursors become the ligaments.

adjacent groups by ligaments from its column precursors to the precursors of other groups.

The ligaments 17 have been etched to half the thickness of the plate 10 as shown in the sectional view of Figure 3.

It will be appreciated that the ligament and column precursor arrangement can vary widely from that shown.

In Figure 4 the central region of plate 20 has an array of rectangular section column precursors 21 in rows, each column precursor in one row being attached to an adjacent precursor in the next row or rows by a diagonally-extending, relatively thin, i.e. in plan, ligament 22A or 22B. Ligaments 22A between a first pair of rows of column precursors are angled in the opposite direction to ligaments 22B between the next row and this is repeated across the plate.

In Figure 5, the central region of plate 30 has the same linear array of column precursors 31 as Figure 4. Column precursors 31 have the same dimensions as column precursors 21 of plate 20 and are spaced at the same positions in the plate. Plates 20 and 30 are of identical size.

Column precursors 31 are joined to the adjacent precursors in the same row by ligaments 32 and to adjacent precursors in the next row or rows by ligaments 33.

In another aspect the invention provides a perforated plate having an array of spaced column precursors, the column precursors being of thickness equal to the plate thickness and being joined together by ligaments extending between adjacent pairs of column precursors, the ligaments having a thickness less than the plate thickness.

The top and bottom of the stack may be closed by conventional solid plates, and inlet, outlet, header tank and like features may be provided as required. Side plates or bars of the stack may conveniently be formed by the stacking of unperforated border regions around the edges of individual plates of the stack, the unperforated border regions being integrally formed as part of the plate.

Preferably the perforations in the plates and the reduced thickness of the ligaments are both provided by photochemically etching, such a technique being well known in the art. However other means, e.g. spark erosion, may be used, if desired.

It is preferred that at least two different patterns of ligaments are used so that the ligaments do not completely coincide through the stack. Preferably at least two different plates are provided, i.e. the plates have different ligament patterns. Thus a tortuous flow path through the stack is provided around and normal to the longitudinal axes of the columns and across the surfaces of the ligaments.

In practice, however, it has proved difficult to make a satisfactory pin fin stack. It has proved difficult to maintain the pins at their correct spacing relative to each other while creating the necessary conditions, e.g. of temperature and pressure, for satisfactory bonding of the plates and the pins to take place.

It is, therefore, an object of the present invention to provide improved pin-fin heat exchangers that can be accurately and consistently manufactured to the required tolerances and that have improved heat exchange capability

Accordingly, in one aspect the invention provides a heat exchanger, the heat exchanger comprising a stack of parallel perforated plates, each plate of the stack having perforations defining an array of spaced column precursors, of thickness equal to the plate thickness, the column precursors being joined together by ligaments extending between adjacent pairs of column precursors, the ligaments having a thickness less than the plate thickness, the column precursors of any one plate being coincident in the stack with the column precursors of any adjacent plate whereby the stack is provided with columns extending perpendicularly to the plane of the plates.

Preferably the ligaments of each plate of each pair of adjacent plates are displaced relative to those of the other plate of the pair whereby more turbulent fluid flow channels are provided through the stack, i.e. around the columns and under or over each ligament.

DESCRIPTION

HEAT EXCHANGER

This invention relates to heat exchangers and is particularly concerned with heat exchangers of the so-called "pin-fin" type.

"Pin-fin" type heat exchangers have been well known in principle for many years and consist essentially of a stack of thin metal plates, adjacent pairs of plates in the stack being separated by a plurality of spaced columns - or pins. Fluid flowing through the stack passes between adjacent pairs of plates and is forced to follow a tortuous path to flow around the pins in its travel from one side of the stack to the other. Such flow, and the turbulence caused by the pins, leads, theoretically, to good heat transfer properties for the stack.

The pins are essentially columns of solid metal which have to be bonded at their ends to a pair of plates so that the pins are sandwiched between and perpendicular to the plates. The plates form the primary surfaces of the heat exchanger and separate different flow streams and the pins provide secondary surface areas.

Preferably, the pins need to be bonded, e.g. by brazing, welding, diffusion bonding or any other possible means, in a manner to minimise surface contact resistance.

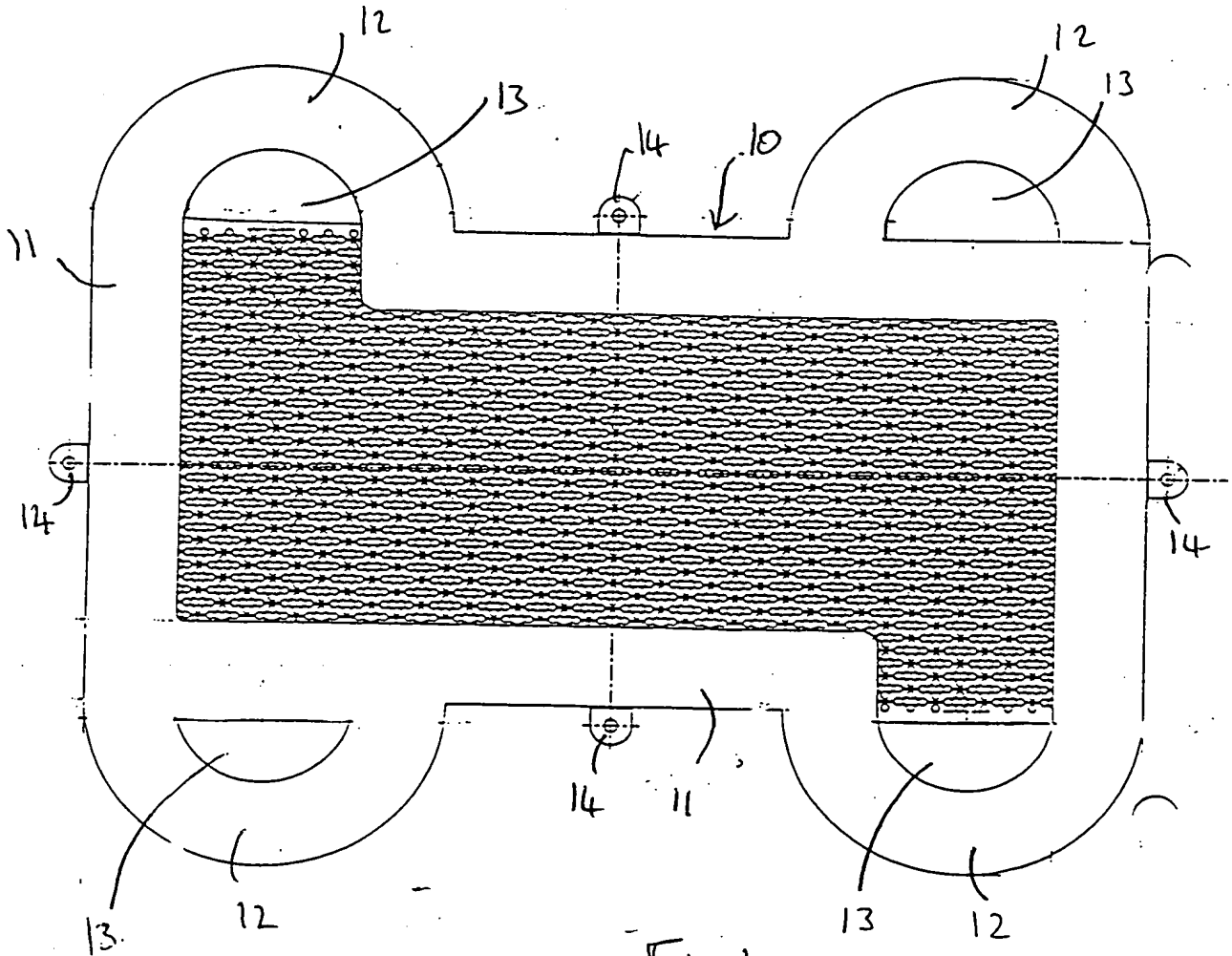

Fig. 1

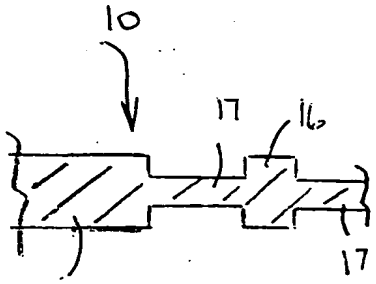

Fig. 3

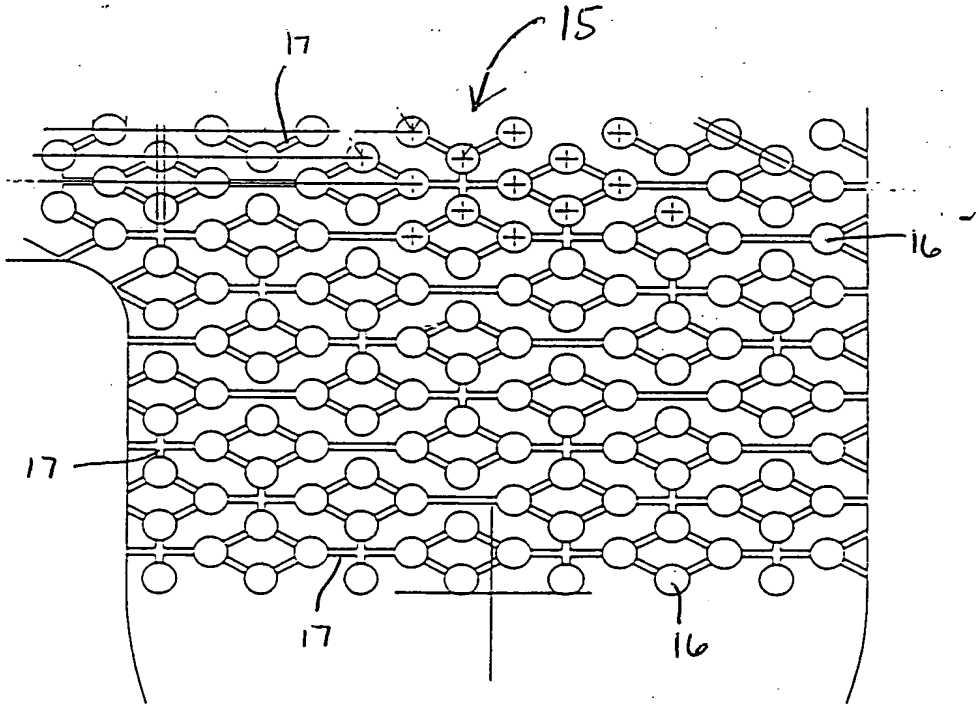

Fig 2

PCT/GB99/01622

18th June 1999

J. H. Moore & Co.